



#4



INVESTOR IN PEOPLE

The Patent Office
Concept House
Cardiff Road
Newport
South Wales
NP10 8QQ



I, the undersigned, being an officer duly authorised in accordance with Section 74(1) and (4) of the Deregulation & Contracting Out Act 1994, to sign and issue certificates on behalf of the Comptroller-General, hereby certify that annexed hereto is a true copy of the documents as originally filed in connection with the patent application identified therein.

In accordance with the Patents (Companies Re-registration) Rules 1982, if a company named in this certificate and any accompanying documents has re-registered under the Companies Act 1980 with the same name as that with which it was registered immediately before re-registration save for the substitution as, or inclusion as, the last part of the name of the words "public limited company" or their equivalents in Welsh, references to the name of the company in this certificate and any accompanying documents shall be treated as references to the name with which it is so re-registered.

In accordance with the rules, the words "public limited company" may be replaced by p.l.c., plc, P.L.C. or PLC.

Re-registration under the Companies Act does not constitute a new legal entity but merely subjects the company to certain additional company law rules.

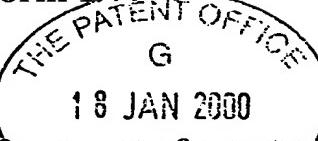
CERTIFIED COPY OF
PRIORITY DOCUMENT

Signed

Dated 14 November 2000



This Page Blank (uspto)



Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form.)

19 JAN 00 E506323-3 D02924
P01/7700 0.0 The Patent Office

Cardiff Road
Newport
Gwent NP9 1RH

1. Your reference

625 P/2990(7255)

2. Patent application number

(The Patent Offic

0001157.7

18 JAN 2000

3. Full n.
ame _____ postcode of the or
each applicant (underline all surnames)

607 65600 6

MITEL CORPORATION

350 LEGGET DRIVE
P.O Box 13089
KANATA
ONTARIO K2K 2W7

21/1/2000
(xx/a/c
21/1/2000)

Patents ADP number (if you know it)

If the applicant is a corporate body, given
the country/state of its incorporation

Canada

4. Title of the invention

PACKET LOSS COMPENSATION METHOD USING
INJECTION OF SPECTRALLY SHAPED NOISE

5. Name of your agent

Stephenson Harwood

"Address for service" in the United
Kingdom to which all correspondence
should be sent

One, St. Paul's Churchyard
London
EC4M 8SH

Patents ADP number

05888938001 ✓

6. If you are declaring priority from one or
more earlier patent applications, give the
country and the date of filing of the or of
each of these earlier applications and (if you
know it) the or each application number

Country

Priority application number

Date of filing
(day/month/year)

7. If this application is divided or otherwise
derived from an earlier UK application,
give the number and the filing date of the
earlier application

Number of earlier application

Date of filing
(day/month/year)

8. Is a statement of inventorship and of right
to grant of a patent required in support of
this request? (Answer 'Yes' if:
a) any applicant named in part 3 is not an inventor,
or
b) there is an inventor who is not named as an
applicant, or
c) any named applicant is a corporate body.

Yes

REST AVAILABLE COPY

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document.

Continuation sheets of this form 0

Description 4

Claims(s) 2

Abstract 1

Drawing(s) 3 + 3 14

10. If you are also filing any of the following, state how many against each item.

Priority documents

Translations of priority documents

Statement of inventorship and right to grant of a patent (*Patents Form 7/77*) 4

Request for preliminary examination and search (*Patents Form 9/77*) 1

Request for substantive examination
(*Patents Form 10/77*) 1

Any other documents

11.

I/We request the grant of a patent on the basis of this application.

Signature

Nikles Hedley
8 tealson blwood
N J M Hedley
0171 329-4422

Date: 18 January 2000

12. Name and daytime telephone number of person to contact in the United Kingdom

Warning

After an application for a patent has been filed, the Comptroller of the Patent Office will consider whether publication or communication of the invention should be prohibited or restricted under Section 22 of the Patents Act 1977. You will be informed if it is necessary to prohibit or restrict your invention in this way. Furthermore, if you live in the United Kingdom, Section 23 of the Patents Act 1977 stops you from applying for a patent abroad without first getting written permission from the Patent Office unless an application has been filed at least 6 weeks beforehand in the United Kingdom for a patent for the same invention and either no direction prohibiting publication or communication has been given, or any such direction has been revoked.

PACKET LOSS COMPENSATION METHOD USING INJECTION OF SPECTRALLY
SHAPED NOISE

FIELD OF THE INVENTION

5

This invention relates in general to packetized voice communication systems, and more particularly to a method of compensating for lost packets in a packetized voice system by injecting spectrally shaped noise.

10 BACKGROUND OF THE INVENTION

Transmission of voice over packet networks has emerged in recent years as a replacement for traditional legacy PBX systems for telephone communications. A packetized voice transmission system comprises a transmitter and a receiver. The transmitter collects 15 voice samples and groups them into packets for transmission across a network to the receiver. The data itself may be companded according to u-law or A-law, as defined in ITU-T specification G.711. Other companding/vocoding techniques, such as G.729, G.723.1, can also be used.

20 When using a packet based network, packet losses due to congestion in the network can produce significant degradation of the performance of echo cancellers. The effects introduced by packet loss depend to a large extent on the techniques used to recover lost packets. Packet loss recovery techniques can be divided into two classes: sender-based repair and receiver-based repair [see C. Perkins, O. Hodson and V. Hardman, "A Survey of Packet 25 Loss Recovery Techniques for Streaming Audio," IEEE Network, Sept./Oct. 1998, pp. 40-48]. Receiver-based repair is also referred to in the art as error concealment.

Among known error concealment techniques, those based on packet insertion have found popularity due to ease of implementation. According to such insertion-based recovery 30 techniques a replacement packet is inserted to fill the gap left by a lost packet. The replacement packet can be one of either silence, white noise or repetition of the previous packet. Silence substitution is simple to implement but performs poorly. Since silence substitution fills the gap left by a lost packet with silence in order to maintain the timing

relationship between the surrounding packets, the performance of silence substitution degrades rapidly as packet sizes increases, and quality is unacceptably bad for the 40 ms packet size in common use in network audio conferencing tools. Some studies have shown that inserting white noise, instead of silence, can improve intelligibility [see G. A. Miller and 5 J. C. R. Licklider, "The Intelligibility of Interrupted Speech," *J. Acoust. Soc. Amer.*, vol. 22, no. 2, 1950, pp. 167-73; and R. M. Warren, *Auditory Perception*, Pergamon Press, 1982]. Among the three methods of packet insertion, repetition of the previous packet gives best voice quality due to the similarity between the neighboring voice segments.

10 Although the uses of white noise and previous packets may yield better speech quality than silence substitution does, these techniques interfere with proper operation of network echo cancellers. The substitution of white noise results in a sudden change in the spectral characteristics of the signal, causing severe degradation of echo return loss enhancement (ERLE). When substituting a previous packet, the fill-in packet is the same as the previous 15 packet, which means that the two packets are highly correlated. This reduces the convergence rate and results in slow recovery from the packet loss.

SUMMARY OF THE INVENTION

20 According to the present invention, a new insertion-based error concealment method and apparatus are provided whereby, instead of directly inserting white noise, a filter is created to shape the white noise. The filtered white noise is then used to replace lost data. The method of the present invention is implemented by first estimating the power spectrum of the previous frame; then designing a filter with transfer function $H(f)$, where $|H(f)|^2$ =the estimated 25 power spectrum; and finally generating the replacement packet using noise which has been spectrally modified by the filter. The resulting filtered noise has the same power spectrum as the previous packet but is not highly correlated with it.

BRIEF DESCRIPTION OF THE DRAWINGS

30 A detailed description of a preferred embodiment of the present invention is provided herein below with reference to the drawings in which:

Figure 1 is a block diagram showing a lost packet generator for use in a data packet transmission system according to the present invention;

5 Figure 2 is a flowchart showing steps in the lost packet compensation method of the present invention; and

Figure 3 is a graph showing a comparison of the impact of packet loss compensation on ERLE using the method and apparatus of the present invention with the prior art.

10 DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

With reference to Figures 1 and 2, a new apparatus and method are shown according to the preferred embodiment, for packet loss compensation in a voice communication system. A buffer 3 receives and stores successive frames of received voice data. A packet loss detector 5 detects lost packets and in response operates a pair of switches 7 and 9, as discussed in greater detail below. The design and operation of buffer 3 and packet loss detector 5 will be well known to a person of ordinary skill in the art and are not, therefore, 15 discussed in further detail herein.

20 In response to detecting a lost packet, switch 7 closes and the previous voice packet stored in buffer 3 is applied to power spectrum estimator 11. Power estimator 11 implements Welch's averaged periodogram method for estimating the power signal $P(\omega)$, (see P. D. Welch, "The Use of Fast Fourier Transform for the Estimation of Power Spectra", IEEE Trans. Audio Electroacoust., Vol AU-15, June 1970, pp. 70 - 73), although any spectral 25 estimation algorithm will suffice. The output of the spectrum estimator is sent to a filter coefficients calculator 13. The filter coefficients calculator 13 designs an FFT filter 15 with transfer function $H(f)$, where $|H(f)|^2$ =the estimated power spectrum. filter coefficients calculator 13 and filter 15 may be implemented using a digital signal processor (DSP) using well known techniques. According to a successful implementation a 64 bit FFT was used. 30 White noise is output from generator 17 to the filter 15 so that the shapes the white noise to the characteristics of the voice signal. As indicated above, packet loss detector 5 operates switch 9 so that in response to a lost packet, the filtered noise from filter 15 is output to replace lost data. The filtered noise has the same power spectrum as the previous frame. Due

to the similarity between the neighboring frames, the filtered noise is more similar to the lost packet than unfiltered white noise is.

Figure 3 shows the comparative ERLE performance of the lost packet compensation method of the present invention relative to other techniques. It can be seen that inserting silence and white noise exhibit the smallest and greatest impact on the ERLE performance, respectively. However, the degradation of ERLE is smaller using the system according to the present invention than when using substitution of white noise, and the impact on ERLE decays quicker compared to the substitution of previous packets.

10

Alternative embodiments and variations of the invention are possible. For example, although the inventive method and apparatus have been described in terms of voice transmission over IP networks, it is contemplated that the principles of the invention may be extended to other asynchronous systems such as ATM networks. Also, whereas the preferred embodiment sets forth the use of Welch's algorithm and an FFT filter for spectral estimation and filtering, respectively, it is possible to use other spectral estimation algorithms (e.g. Linear Predictive Coding (LPC)), and other filtering (e.g. using LPC coefficients).

15

All such changes and modifications may be made without departing from the sphere and scope of the invention as defined by the claims appended hereto.

20

What is claimed is:

1. A method of compensating for lost packets in a packet based voice communication system, comprising the steps of:

5

storing successive packets of a packetized voice signal;

detecting a missing voice packet from said voice signal;

10 estimating the power spectrum $P(\omega)$ of a stored one of said packets previous to said missing voice packet;

creating a filter with transfer function $|H(\omega)|^2 = P(\omega)$;

15 applying white noise to said filter for generating a noise packet which has the same power spectrum as said stored one of said packets; and

inserting said noise packet in said voice signal to replace said missing voice packet.

20 2. The method of claim 1, wherein said step of estimating said power spectrum comprises performing Welch's averaged periodogram method on said stored one of said packets.

25 3. A system to compensate for lost packets in a packet based voice communication system, comprising:

a buffer for storing successive packets of a packetized voice signal;

a packet loss detector for detecting a missing voice packet from said voice signal;

30

a power spectrum estimator for estimating the power spectrum $P(\omega)$ of a stored one of said packets previous to said missing voice packet;

a filter coefficients generator for receiving said power spectrum from said power spectrum estimator and in response creating a filter with transfer function $|H(\omega)|^2 = P(\omega)$;

5 a white noise generator for applying white noise to said filter which in response generates a noise packet which has the same power spectrum as said stored one of said packets; and

10 a switch operable by packet loss detector for inserting said noise packet in said voice signal to replace said missing voice packet.

4. The system of claim 3, further comprising an additional switch operable by said packet loss detector and connected between said buffer and said power spectrum estimator.

5. The system of claim 3, wherein said power spectrum estimator implements Welch's averaged periodogram method on said stored one of said packets.

15 6. A method according to claim 1 or 2, or system according to any of claims 3 to 5, substantially as herein described with reference to and as shown in the accompanying drawings.

ABSTRACTPACKET LOSS COMPENSATION METHOD USING INJECTION OF SPECTRALLY SHAPED NOISE

An insertion-based error concealment method and apparatus are provided whereby,
5 instead of directly inserting white noise, a filter is created to shape the white noise. The
filtered white noise is then used to replace lost data. The method of the present invention is
implemented by first estimating the power spectrum of the previous frame; then designing a
filter with transfer function $H(f)$, where $|H(f)|^2$ =the estimated power spectrum; and finally
generating the replacement packet using noise which has been spectrally modified by the
10 filter. The resulting filtered noise has the same power spectrum as the previous packet but is
not highly correlated with it.

(Figures 1 & 2)

This Page Blank (uspto)

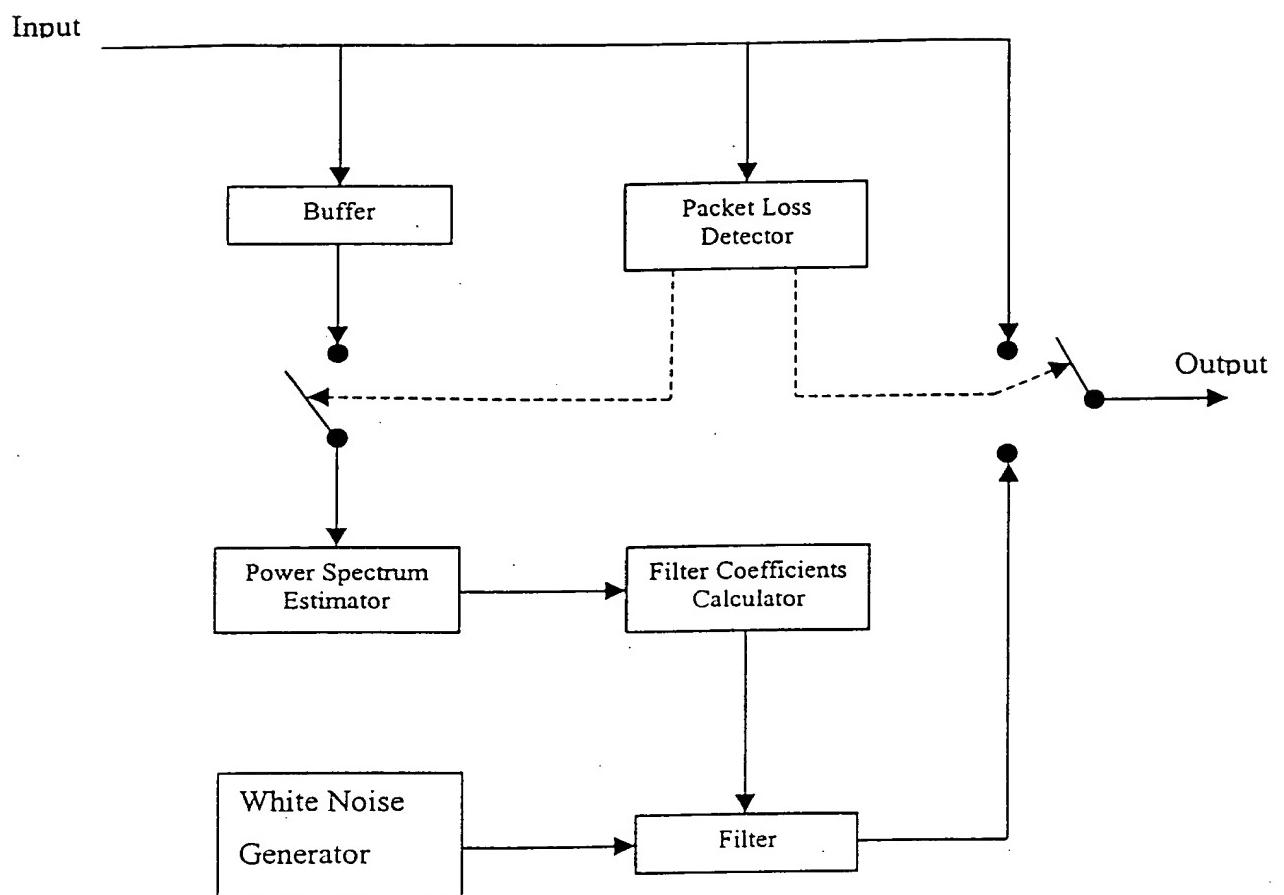


Figure 1

Start

This Page Blank (uspto)

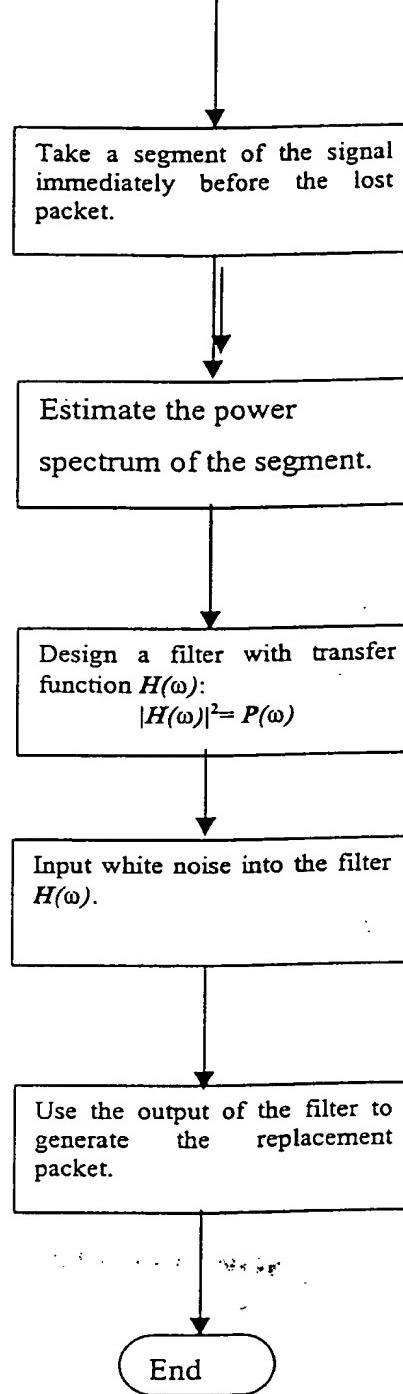


Figure 2

This Page Blank (uspto)

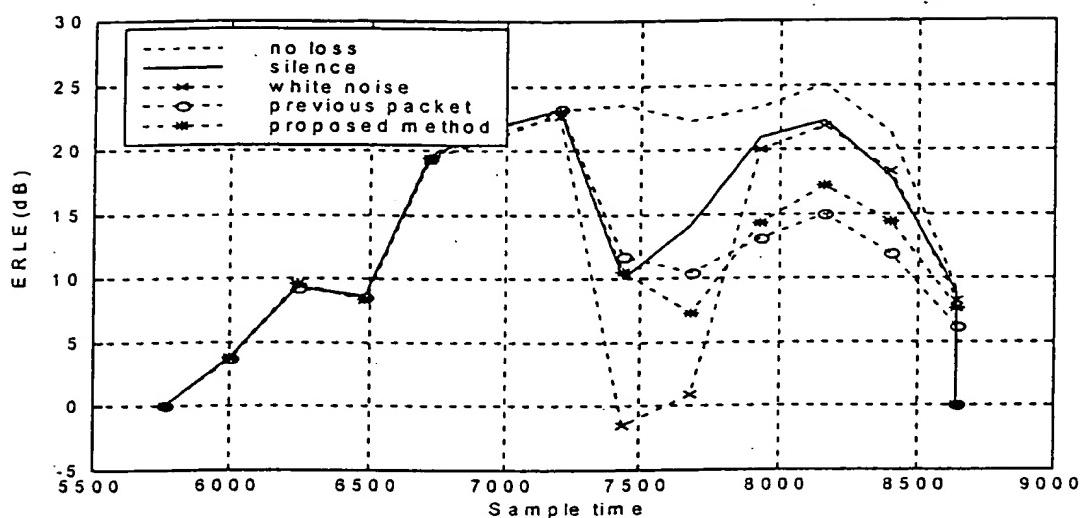


Figure 3

This Page Blank (uspto)

**This Page is Inserted by IFW Indexing and Scanning
Operations and is not part of the Official Record**

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- BLACK BORDERS**
- IMAGE CUT OFF AT TOP, BOTTOM OR SIDES**
- FADED TEXT OR DRAWING**
- BLURRED OR ILLEGIBLE TEXT OR DRAWING**
- SKEWED/SLANTED IMAGES**
- COLOR OR BLACK AND WHITE PHOTOGRAPHS**
- GRAY SCALE DOCUMENTS**
- LINES OR MARKS ON ORIGINAL DOCUMENT**
- REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY**
- OTHER:** _____

IMAGES ARE BEST AVAILABLE COPY.

As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.

This Page Blank (uspto)